

EFFECT OF GRANITE WASTE AND MINERAL ADMIXTURES ON STRENGTH PROPERTIES OF CONCRETE

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ABSTRACT

Concrete is the most multipurpose material. The wastes in the form of powder generated from granite industry during the process of cutting and polishing of granite rocks. This granite waste mainly pollute the environment. Therefore, this project aim is to utilize the granite waste in the effective way, an experimental investigation is carried out. The strength properties of M30 grade concrete such as Compressive Split tensile and Flexural strengths are studied with different percentage of replacements 5%, 10%, 15%, 20%, 25% of fine aggregate by granite waste (GW). The optimum percentage of granite waste replacement in concrete corresponding to maximum strengths will be identified. Keeping this optimum percentage of granite powder replacement as constant, cement replacement study with mineral admixtures (MA) such as Silica Fume (SF) (5%,10%,15%,20%) and Metakaolin (MK) (5%,10%,15%,20%,25%) are carried out separately on strength properties of concrete. With the above study, the maximum strength of concrete corresponding to replacement of Silica Fume and Metakaolin are identified. It was observed that the maximum increase in strength properties compared to conventional concrete was achieved at 15% replacement of granite waste. Based on the results obtained, the combination of GW (15%) with Metakaolin showed better performance than GW (15%) with silica fume. The details of the investigation along with the results are present in this report.

KEYWORDS: Granite Waste, Silica Fume, Metakaolin, Super Plasticizer, Strength Properties

INTRODUCTION

Concrete has been a leading construction material for over a century. The wastes generated from granite and marble industry can be effectively utilized in concrete so that reducing the environmental pollution. This industrial waste can also be used as replacing the fine aggregate, replacing the cement or addition of cement in concrete mix. This waste can increase the strength properties of concrete. The waste used in this investigation is produced at kallur industrial area in Kurnool, AP. The total wastes produced from the granite polishing industries is approximately 300 tonnes per day. Only some quantity is utilized and the remaining quantity is dumped in open areas, creating the environmental pollution. Hence this wastes can be used in effective way as to replace the fine aggregate, which can improve the mechanical properties of concrete. Using of chemical admixtures like plasticizer and super plasticizers would reduce the water content in the cement paste, thereby reducing the porosity in the cement paste. The cement replacing materials also called as mineral admixtures such as Silica Fume, Flyash, GGBS, GBS, Metakaolin. Using of these cement replacement materials individually or in combination with other materials can improve the mechanical properties and durability properties of concrete. The cement replacement materials used in this investigation were Silica Fume and Metakaolin. Cement replacement materials along with super plastisizers can improve the strength properties of concrete. The selection and dosage of super plastisizer is very

important for making of high performance concrete. Thus the investigation has been carried out to evaluate the use of granite waste as fine aggregate replacement together with Silica Fume and Metakaolin as partial replacement of cement.

LITERATURE REVIEW

Several authors have reported the use of granite waste in various civil engineering applications.

Manasseh Joel: Reported that the suitability of Crushed granite fine (CGF) to replace river sand in concrete production for use in rigid pavement was investigated. Based on economic analysis and test results, river sand replaced with 20% CGF is recommended dosage in the production of concrete for use in rigid pavement. When Makurdi river sand was replaced with 20% CGF in concrete high compressive strength and indirect tensile strength values of 40.70N/mm² and 2.30N/mm² respectively were obtained.

T. Felixkala and T. Partheeban: Had reported that fine aggregate is replaced with granite powder and cement is partial replaced with 10% fly ash, 7.5% silica fume, 10% slag and dosage of super plasticiser added is 1% by weight of cement in concrete with 0.4 water to-binder (w/b) ratios on the effects of water ponding temperatures at 26⁰C and 38⁰C and tested for mechanical properties. From the test results shows that concrete with 25% of granite powder (GP25) was found to be higher to other mixtures as well as GP0 and NA100 for all operating conditions.

Dr.G.Prince Arulraj, et al: Had investigated that fine aggregate is replaced with granite powder by weight were 0%,5%,10%,20%,25% with 0.5% super plasticizer. The optimum dosage of replacement of fine aggregate with granite powder is found to be 15% based on test results.

Arivumangai, et al: Had investigated that fine aggregate is replaced with granite powder and cement is partial replaced with 10% fly ash, 7.5% silica fume, 10% slag and dosage of super plasticiser added is 1% by weight of cement in concrete for M30 grade concrete and tested for 28,56,90 days. Based on test results obtained there will be enhanced in the chemical resistance of concrete when fine aggregate is replaced with 25% granite powder.

Divakar Y: Had investigated that fine aggregate is replaced with granite fines by weight were 5%,15%,25%,35%,50% for M20 grade concrete with water cement ratio of 0.6 and tested for strength properties such as Compressive, Split tensile and Flexural strengths and results are compared with conventional concrete without granite fines. The maximum replacement of fine aggregate with granite fines is found to be 35%.

Dr.T. Felix Kala: Had investigated that fine aggregate is replaced with granite powder by weight was 0%,25%,50%,75%,100% and cement is partial replaced with 7.5% silica fume, 10% fly ash, 10% slag and dosage of super plasticizer added is 1% by weight of cement in concrete for HPC to obtained the maximum strength of 60Mpa for 28 days. They concluded that mechanical properties are enhanced with the effective utilization of granite powder in the replacement of fine aggregate.

Muritala Ashola ADIGUN et al: Had reported that fine aggregate is replaced with Crushed Granite Fines for nominal mixes 1:1:2 and 1:1.5:3 and compressive and slump tests are conducted. The maximum compressive strength was obtained as 30 & 35 when fine aggregate is replaced with 25-37.5% crushed granite fines for nominal mixes of 1:1:2 and 1:1.5:3 respectively.

Research Objectives

The present study involves addition of silica fume, metakaolin, superplasticizer and granite waste for conventional concrete. Therefore, the study had several typical objectives.

- The first aim was to estimate an optimal replacement of fine aggregate with granite waste was find out.
- The other objective of this work was to determine the maximum strength with respect to silica fume and metakaolin for cement replacement by keeping granite waste replacement constant.
- Further, to determine the degree of strength improvement in concrete obtained with the addition of granite waste with admixtures.

EXPERIMENTAL PROGRAM

Materials

Ordinary Portland (53 grade) Zuari cement was used, and its properties are given in Table 1. It met the requirements of Indian Standard Specifications IS 12269 -1987. Super plasticizer used in this project is Master Glenium SKY 8233 is based on poly-carboxylic ether. Its specific gravity is 1.08. The properties of the metakaolin and silica fume are given in Table2. Locally available river sand was used as a fine aggregate. Granite waste was used as a fine aggregate replacement. The size of granite waste used in this project is between 2.36μ - 150μ . They were tested as per Indian Standard Specifications IS: 383–1970 and their physical properties are given in table 3. Coarse aggregate used in this study were less than 20 mm nominal size, and were tested as per Indian Standard Specifications IS: 383–1970 and its physical properties are given in Table 3.

Table 1: Properties of Cement

S.NO	Physical Tests	Results Obtained	Standard Value as Per IS Code 12269-1987
1.	Fineness	4.9%	Not >10% as per IS 4031 part 1
2.	Consistency	31.5%	IS 4031 part 4
3.	Initial Setting Time	42min	Not less than 30 min as per IS 4031 part 5
4.	Final Setting Time	310min	Not more than 600 min as per IS 4031 part 5
5.	Soundness	3mm	Not >10mm as per IS 4031 part 3
6.	Specific gravity	3.12	IS 2720 part 3
7.	Compressive strength	56 N/mm ²	Not be less than 53N/mm ²

Table 2: Properties of Metakaolin and Silica fume Table 3. Properties of Aggregate

Characteristics	Metakaolin	Silica Fume
Colour	creamish	White
Specific gravity	2.5	2.63
Size (μ m)	5	10
Surface area(m ² /gm)	20	15

Table 3

Characteristics	Specific Gravity	Fineness Modulus
Fine Aggregate	2.65	2.7
Granite waste	2.58	2.45
Coarse Aggregate	2.73	4.6

Preparation and Casting of Specimens

The different concrete specimens such as cubes (150mmX150mmX150mm) to determine compressive strength, cylinders (150mm diameter and 300mm length) to determine split tensile strength and beams (100mmX100mmX500mm) to determine flexural strength were cast. All the specimens were prepared in accordance with Indian Standard Specifications IS: 516-1959. All the moulds were cleaned and oiled properly. These were securely tightened to correct dimensions before casting. Care was taken that there is no gaps left from where there is any possibility of leakage of slurry. A careful procedure was adopted in the batching, mixing and casting operations. Vibrations were stopped as soon as the cement slurry appeared on the top surface of the Mould. The specimens were removed from moulds after 24 hours and cured in water till testing or as per requirement of the test.

Experimental Procedure

Experiment investigation has been carried out with reference to mix M30 grade concrete. Fifteen concrete mixes were prepared. Reference mix (M0) was prepared for M30 grade of concrete as per IS: 10262-2009. Five concrete mixes (M1, M2, M3, M4, M5) were prepared where fine aggregate was replaced with 5%, 10%, 15%, 20%, and 25% granite waste by weight respectively. It has been observed that concrete with 15% replacement of granite waste attains maximum strength properties. Hence 15% replacement of granite waste was kept constant and cement replacement study with minerals admixtures such as silica fume at 5%, 10%, 15%, 20% (M6, M7, M8, M9) and metakaolin at 5%, 10%, 15%, 20%, 25% (M10, M11, M12, M13, M14) were carried out with water-cement ratio of 0.43. The mix proportion of all mixes are shown in table 4.

RESULTS AND DISCUSSIONS

Fresh and Hardened Concrete Properties

The workability of fresh concrete is a composite property which includes the diverse requirements of stability, mobility, compactibility, placeability, and finishability. Compaction factor tests were performed as per BIS: 1199-1959. The test consists essentially of applying a standard amount of work to standard quantity of concrete and measuring the resulting compaction. As percentage replacement of granite waste is increased in concrete its workability decreases. Compaction factor (C.F) values of all mixes are shown in table 4.

Compressive Strength

It was observed that the increase in compressive strength was observed gradually up to 15% replacement of fine aggregates by granite waste and then decreased. The mix with 15% granite waste replacement obtained maximum compressive strength of 45.185 N/mm². Maximum compressive strength of mix (M3) with 15% granite waste which was 17.32% more compared to reference mix. Variation of compressive strength of M30 grade with different percentage replacement of fine aggregate by granite waste is shown in figure 1.

Compressive strength of M30 grade were studied keeping 15%GW replacement constant and varying cement replacement by SF at different percentages 5%,10%,15%,20%. The maximum compressive strength was obtained at 15% granite waste and 15% silica fume among all silica fume replacement mixes. If silica fume percentage in concrete increased beyond 15% its compressive strength decreased. Mix which was replaced by 15% of granite waste and 15% silica fume (M8) obtained a compressive strength 58.370N/mm^2 which was 29.180% more than the reference mix (M0). It has more strength than mix with 15% replacement by granite waste (M3). Variation of compressive strength of concrete with 15% granite waste and different percentage of silica fume as shown in figure 4.

Compressive strength of M30 grade were also studied with combination of 15% granite waste and 5%,10%,15%,20%,25% metakaolin replaced with cement. Mix with M30 grade with 15% granite waste and 15% metakaolin obtained maximum strength among all metakaolin replacement mixes. If metakaolin percentage in concrete increased beyond 15% its compressive strength decreased. Mix with 15% replacement granite waste and 15% metakaolin (M12) replacement obtained compressive strength 62.66N/mm^2 which was 38.687% more than the reference mix (M0). Variation of compressive strength of concrete with 15% granite waste and different percentage of metakaolin in shown in figure 4. Percentage increase of compressive strength of different mixes compare to M3 mix are shown are in table 5.

Table 4: Mix Proportions

MIX NO	M0	M1	M2	M3	M4	M5	M6	M7	M8	M9	M10	M11	M12	M13	M14
Cement (Kg/m ³)	366.8	366.8	366.8	366.8	366.8	366.8	348.4	330.1	311.7	293.4	348.4	330.1	311.7	293.4	275.1
Sand (Kg/m ³)	680.8	646.8	578.7	544.6	510.6	578.7	578.7	578.7	578.7	578.7	578.7	578.7	578.7	578.7	578.7
G.W (%)	0	5	10	15	20	25	15	15	15	15	15	15	15	15	15
G.W (Kg/m ³)	0	32.34	61.27	86.81	108.9	127.6	86.81	86.81	86.81	86.81	86.81	86.81	86.81	86.81	86.81
C.A (Kg/m ³)	1215	1215	1215	1215	1215	1215	1215	1215	1215	1215	1215	1215	1215	1215	1215
Water (kg/m ³)	157.7	157.7	157.7	157.7	157.7	157.7	157.7	157.7	157.7	157.7	157.7	157.7	157.7	157.7	157.7
S.P(%)	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
W/C ratio	0.43	0.43	0.43	0.43	0.43	0.43	0.43	0.43	0.43	0.43	0.43	0.43	0.43	0.43	0.43
S.F (%)	0	0	0	0	0	0	5	10	15	20	0	0	0	0	0
S.F (Kg/m ³)	0	0	0	0	0	0	348.4	330.1	311.7	293.4	0	0	0	0	0
M.K (%)	0	0	0	0	0	0	0	0	0	0	5	10	15	20	25
M.K (Kg/m ³)	0	0	0	0	0	0	0	0	0	0	348.4	330.1	311.7	293.4	275.1
C.F	0.951	0.945	0.942	0.935	0.923	0.914	0.937	0.930	0.921	0.910	0.936	0.924	0.918	0.905	0.898

Split Tensile Strength

The Split tensile strength of reference mix (M0) and all other mixes prepared, using granite waste and silica fume, metakaolin are shown in Table 5.

It was observed that the increase in Split tensile strength with GW was observed gradually up to 15% replacement of fine aggregates by granite waste and then decreased. The maximum Split tensile strength was obtained 3.890 N/mm^2 at 15% granite waste. Maximum Split tensile strength was obtained with mix (M3) 15% granite waste which was 30.97% more compared to reference mix. Variation of Split tensile strength of M30 grade with different percentage replacement of fine aggregate by granite waste in shown in figure 2.

Split tensile strength of M30 grade were studied with combination of 15% granite waste and 5%,10%,15%,20% silica fume replaced with cement. Mix with M30 grade with 15% granite waste and 15% silica fume obtained maximum strength among all silica fume replacements. If silica fume percentage in concrete increased beyond 10% its split tensile strength decreased. Mix which was replaced by 15% granite waste and 10% silica fume (M7) obtained a Split tensile strength 4.456N/mm^2 which was 14.55% more than the mix (M3). Variation of Split tensile strength of concrete with 15% granite waste and different percentages of silica fume as shown in figure 5.

Split tensile strength of M30 grade were also studied with combination of 15% granite waste and 5%,10%,15%,20%,25% metakaolin replaced with cement. Mix with M30 grade with 15% granite waste and 15% metakaolin obtained maximum strength among all metakaolin replacement mixes. If metakaolin percentage in concrete increased beyond 15% its split tensile strength decreased.. Mix with 15% granite waste and 15% metakaolin (M12) replacement obtained Split tensile strength 4.880N/mm^2 which was 25.44% more than the mix(M3). Variation of Split tensile strength of concrete with 15% granite waste and different percentage of metakaolin is shown in figure 5. Percentage increase of split tensile strength of different mixes compare to M3 mix are shown in table 5.

Table 5: Strength Properties of M30 Concrete

Mix no	Compressive strength N/mm^2	compressive strength in percentage	Split tensile strength N/mm^2	Split tensile strength in percentage	Flexural strength N/mm^2	Flexural strength in percentage
M0	38.51	0	2.97	0	2.83	0
M1	39.4	2.31	3.39	14.14	3.01	6.36
M2	43.4	12.69	3.64	22.55	3.33	17.66
M3	45.18	17.32	3.89	30.97	3.63	28.26
M4	40.14	4.23	3.25	9.42	3.26	15.19
M5	37.5	-2.62	2.86	-3.70	2.74	-3.18
M6	43.55	-3.60	3.79	-2.57	3.43	-5.83
M7	51.25	13.43	4.45	14.39	3.89	7.16
M8	58.37	29.19	4.10	5.39	4.50	23.96
M9	45.03	-0.33	3.74	-3.85	3.57	-1.65
M10	44.70	-1.06	3.83	-1.54	3.60	-0.82
M11	55.11	21.97	4.32	11.05	4.29	18.18
M12	60.66	34.26	4.88	25.44	4.87	34.15
M13	53.62	18.68	3.96	1.79	4.41	21.48
M14	44.29	-1.96	3.46	-11.05	3.51	-3.30

Flexural Strength

The Flexural strength of reference mix (M0) and all other mixes prepared, using granite waste, silica fume and metakaolin are shown in Table 5.

It was observed that the increase in flexural strength with GW was observed gradually up to 15% replacement of fine aggregates by granite waste and then decreased. The maximum flexural strength was obtained 3.63 N/mm^2 at 15% granite waste. Maximum flexural strength was obtained with mix (M3) 15% granite waste which was 28.268% more compared to reference mix(M0). Variation of flexural strength of M30 grade with different percentage replacement of fine aggregate by granite waste in shown in figure 3.

Flexural strength of M30 grade were studied with combination of 15% granite waste and 5%,10%,15%,20% silica fume replaced with cement. Mix with M30 grade with 15% granite waste and 15% silica fume obtained maximum strength

among all silica fume replacements. If silica fume percentage in concrete increased beyond 15% its flexural strength decreased. Mix which was replaced by 15% granite waste and 15% silica fume (M7) obtained a flexural strength 4.50N/mm^2 which was 23.966% more than the mix (M3). Variation of flexural strength of concrete with 15% granite waste and different percentages of silica fume as shown in figure 6.

flexural strength of M30 grade were also studied with combination of 15% granite waste and 5%,10%,15%,20%,25% metakaolin replaced with cement. Mix with M30 grade with 15% granite waste and 15% metakaolin obtained maximum strength among all metakaolin replacement mixes If metakaolin percentage in concrete increased beyond 15% its flexural strength decreased.. Mix with 15% granite waste and 15% metakaolin (M12) replacement obtained flexural strength 4.87N/mm^2 which was 34.149% more than the mix(M3). Variation of flexural strength of concrete with 15% granite waste and different percentage of metakaolin is shown in figure 6. Percentage increase of flexural strength of different mixes compare to M3 mix are shown are in table 5.

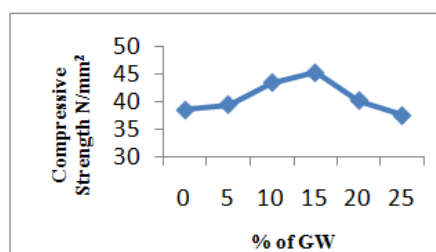


Figure 1: Relation between the Percentages of Granite Waste and Compressive Strength

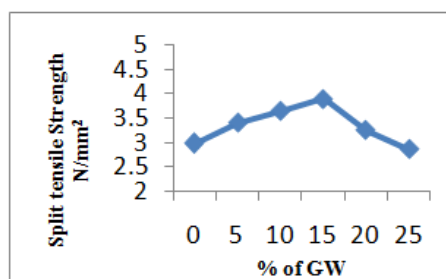


Figure 2: Relation between the Percentages of Granite Waste and Split Tensile Strength

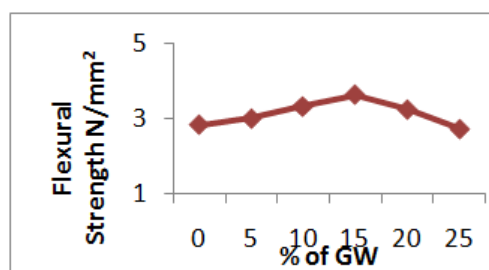


Figure 3: Relation between the Percentages of Granite Waste and Flexural Strength

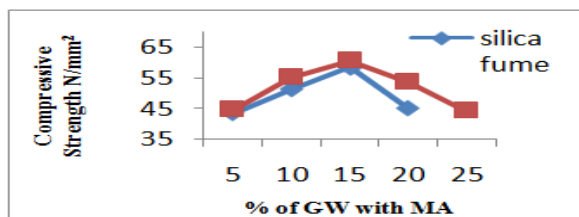


Figure 4: Relation between the Percentages of Granite Waste with Mineral Admixture and Compressive Strength

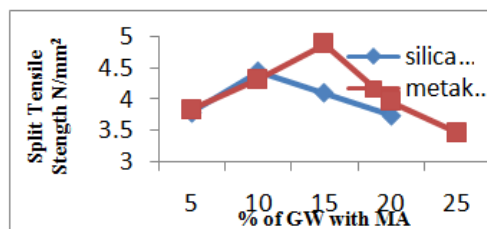


Figure 5: Relation between the Percentages of Granite Waste with Mineral Admixture and Split Tensile Strength

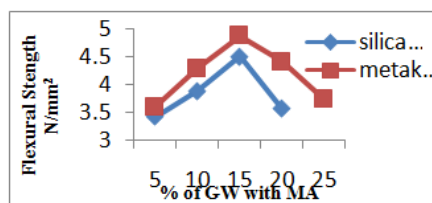


Figure 6: Relation between the Percentages of Granite Waste with Mineral Admixture and Flexural Strength

CONCLUSIONS

Based on above study the following observation are made regarding the strength properties of concrete on partial replacement of fine aggregate by granite waste and cement by minerals admixture such as Silica fume and metakolin. Compressive strength, split tensile strength and flexural strength of M30 grade were increased gradually up to replacement level 15% GW and then decreased. The workability of both M30 grade concrete was decreased with increase in replacement levels of GW, SF and MK in concrete. Maximum compressive strength, split tensile strength and flexural strength with replacement of fine aggregate by 15% GW for M30 grade concrete is 17.32%, 30.97% and 28.26% over reference mix of M30 grade. Maximum compressive strength, split tensile strength and flexural strength with replacement of cement by 15% SF and fine aggregate by 15% GW for M30 grade concrete is 51.57%, 49.83% and 59.01% over reference mix and 29.18%, 14.55% and 23.96% compared with 15% GW of M30 grade respectively. Maximum compressive strength, split tensile strength and flexural strength with replacement of cement by 15% MK and fine aggregate by 15% GW for M30 grade concrete is 57.51%, 64.30% and 72.08% over reference mix and 38.96%, 25.44% and 34.14% compared with 15% GW of M30 grade respectively. Based on experimental results, it was observed that there is significance improvement in the strength properties of concrete with granite waste and metakaolin combination when compared to granite waste and silica fume.

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